

AD 696918

FTIC-WT-23-013-70

U.S. ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER



SOME CHARACTERISTICS OF VERTICAL VARIABILITY OF THE WIND
VELOCITIES IN THE ATMOSPHERIC BOUNDARY LAYER

COUNTRY: USSR

TECHNICAL TRANSLATION

Reproduced by the
CLEARINGHOUSE
for Federal Scientific & Technical
Information, Springfield, Va. 22151

This document has been approved
for public release and sale;
its distribution is unlimited.
It may be released to the
Clearinghouse, Department of
Commerce, for sale to the
general public.

TECHNICAL TRANSLATION

FSTC-HT-23- 013-70

SOME CHARACTERISTICS OF VERTICAL VARIABILITY OF THE WIND
VELOCITIES IN THE ATMOSPHERIC BOUNDARY LAYER

by

P. A. Pershina

Source: TRUDY NAUCHNO-ISSLEDOVATEL'SKOGO
INSTITUTA AEROKLIMATOLOGII,
No. 52, pp. 93-97.
Moscow, USSR

Translated for FSTC by ACSI

This translation is an unedited rendition of the original foreign text. Statements or theories advocated or implied are those of the source and do not reflect the position or opinion of the US Army Foreign Science and Technology Center. This translation is published with a minimum of copy editing and graphics preparation in order to expedite the dissemination of information. Requests for additional copies of this document should be addressed to the Defense Documentation Center, Cameron Station, Alexandria, Virginia, ATTN: TSK-1.

SOME CHARACTERISTICS OF VERTICAL VARIABILITY OF THE WIND
VELOCITIES IN THE ATMOSPHERIC BOUNDARY LAYER

Moscow, Trudy Nauchno-Issledovatel'skogo Instituta Aeroklimatologii (Transactions of the Scientific Research Institute of Aeroclimatology), No. 52, Voprosy Klimatologii (Problems in Climatology), pp. 93-97

P. A. Pershina

In order to solve a great number of practical problems it is highly important to study the characteristics of the regime of meteorological elements in the boundary layer of the atmosphere. In particular, this applies to climatic information on the profiles of meteorological elements, their variability, data on a number of turbulence characteristics, etc.

However, the climatology of the boundary layer is still very poorly developed because research in this field has really only begun. For this reason it is not without interest to give an analysis of some characteristics of the vertical variability of wind velocity based on an analysis of empirical data.

The analysis was based on data from rawin sounding at aerological stations in the USSR (Kiev, Leningrad, Lvov, Minsk, Moscow and Riga) during the period from 1959 through 1963. These data were used in computing the mean and mean square deviations of wind velocity from the vane both for altitudes 0.1, 0.2 and 0.5 km above the ground surface and for 1.0, 1.5, 2.0 and 3.0 km above sea level. In the computations it was taken into account that for a number of known reasons [1-3] the maximum loss of wind information will be at the level $h = 0.1$ km. Accordingly, in order to ensure uniformity of a series of observations in the case of lack of data for the mentioned level

data for the remaining levels are excluded during analysis.

The distribution of probabilities of wind velocity pertains to the type of distribution of essentially positive values. The limitation to a zero limit of the probability function if there is only a single peak gives basis for postulating that the values of the computed parameters (mean \bar{v} and mean square deviations or standard deviation σ) to some degree must be interrelated. However, if there is a calm or weak velocities are close to zero at the height of the vane (10-15 m), a rather common phenomenon, already at a height $h = 0.1$ km they are observed much more infrequently and therefore the influence of the zero limit on the distribution curve is considerably attenuated. Accordingly, the possibility of retention of an interrelationship of these distribution parameters in this case requires a checking and evaluation on the basis of empirical data. This relationship for different altitudes is shown in Fig. 1. Here the dependence of the standard deviation σ on the mean square wind velocity \bar{v} with an error of ± 0.7 (with a 95% reliability average for all altitudes) can also be represented by the following regression equations

$$\begin{aligned}\sigma_v &= 0.21; \bar{v}_v + 1.4; \\ \sigma_{0.1} &= 0.33; \bar{v}_{0.1} + 0.7; \\ \sigma_{0.2} &= 0.37; \bar{v}_{0.2} + 0.7; \\ \sigma_{0.5} &= 0.41; \bar{v}_{0.5} + 0.7; \\ \sigma_H &= 0.45; \bar{v}_H + 0.7.\end{aligned}\tag{1}$$

where H is an altitude corresponding to 1.0, 2.0 and 3.0 km; \bar{v}_v , $\bar{v}_{0.1}$, $\bar{v}_{0.2}$, $\bar{v}_{0.5}$ and \bar{v}_H is the mean monthly velocity for vane altitude, 0.1, 0.2, 0.5 and H km; σ_v , $\sigma_{0.1}$, $\sigma_{0.2}$, $\sigma_{0.5}$ and σ_H are the monthly mean square (standard) deviations for vane altitude, 0.1, 0.2, 0.5 and H km. [See Note]

The regression equations were identical for altitudes 0.1, 2.0 and 3.0 km. Therefore, Fig. 1 for these altitudes gives a common correlation curve and one equation with the subscript H .

[Note: Equations (1) were derived for a range of mean monthly velocities $\bar{v} > 1$ m/sec.]

Equations (1) can be represented in general form in the following way:

GRAPHICS NOT REPRODUCIBLE

$h \geq 0.1$ km
for the vane

$$\begin{aligned}\sigma_h &= A \bar{v}_h + 0.7; \\ \sigma_v &= A v_f + 1.4.\end{aligned}$$

(2)

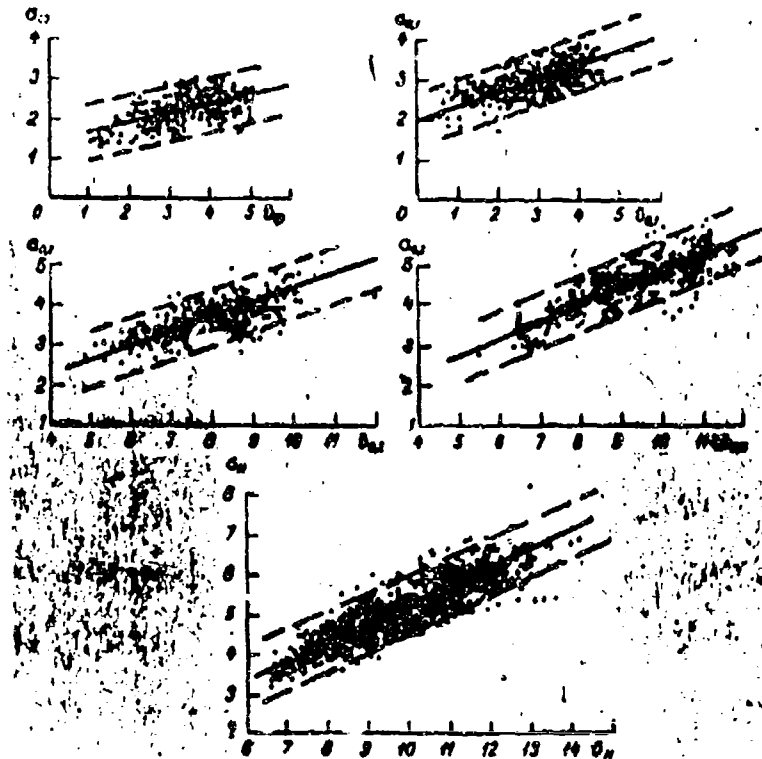


Fig. 1. Dependence of σ on v . φ = vane

It is interesting to note that these relationships are somewhat different according to vane and radiosonde data. Equations (2) show that the free term for radiosonde information has an approximate value 0.7. However, for vane data the free term was twice as great. Here an effect was exerted which is evidently related to the difference in methods for measuring wind velocities (vane and radiosonde) and the characteristics of the wind structure itself in the immediate neighborhood of the earth's surface. However, due to the lack of necessary empirical data a separate evaluation of the measure of the effect of these factors on wind variability is not made in this case and will be investigated later.

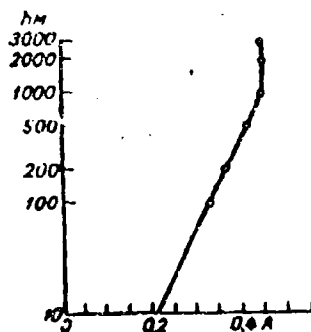


Fig. 2. Dependence of coefficient A on altitude h.

On the other hand, it was found that the coefficient A in equations (1) changes logarithmically from vane level approximately to $h = 1$ km. This dependence is represented in Fig. 2 and is described by the equation:

$$A = 0.12 \log h + 0.09, \quad (3)$$

where h is altitude in meters.

Then equation (2) for $h \gg 0.1$ km can be represented in the form

$$\sigma_h = 0.12 \bar{v}_h \log h + 0.09 \bar{v}_h + 0.7. \quad (4)$$

Thus, in the first approximation the standard deviations of wind velocity in the boundary layer vary with altitude logarithmically.

For the territory of the USSR the mean square wind velocities in the boundary layer at standard levels are widely represented in climatological handbooks and atlases but unfortunately they lack the values of the standard deviations.

Using the derived relations it is also easy to determine the measure of wind velocity variability in this layer.

The practical importance of the derived expressions (1) and (4) increases considerably when direct observational data are lacking for a particular station. In particular, experience shows that in many cases when the mean wind velocities

at the ground exceed 3-4 m/sec the increase in mean wind velocities with altitude in the boundary layer in a lowland area occur (as in the boundary layer) logarithmically. The greater the wind velocity in the free atmosphere, the greater is the slope to the x-axis (Fig. 3). This makes it possible to use wind velocities at two points h_1 and h_2 [See Note] for computing the mean velocity at any other point in the boundary layer h using the following equation:

$$\bar{v}_h \approx \frac{\bar{v}_{h_2} (\lg h - \lg h_1) - \bar{v}_{h_1} (\lg h - \lg h_2)}{\lg h_2 - \lg h_1}, \quad (5)$$

where \bar{v}_h , \bar{v}_{h_1} and \bar{v}_{h_2} are the wind velocities at the levels h, h_1 and h_2 .

[Note: In such cases for the upper boundary of the boundary layer it is desirable that the mean monthly wind velocity not be determined for a single altitude but as the mean of several closely spaced levels.]

If wind velocities are known at the level of the vane $h_1 \approx 10$ m and at the upper boundary of the boundary layer, such as $h_2 \approx 1,000$ m, equation (5) is simplified

$$\bar{v}_h = \frac{\bar{v}_{1000} (\lg h - 1) - \bar{v}_\phi (\lg h - 3)}{2}, \quad (5')$$

[$\phi = v = \text{vane}$].

In those cases when the mean monthly wind velocities at the vane level are unknown, and when the characteristics of the particular station are such that the surface wind profile is considerably influenced by "mesoroughness", the measure of influence of the latter can also be taken into account by using the Sapozhnikova classification [4].

After substituting (5) into (4), we have

$$\begin{aligned} \sigma_h \approx & 0,12 \lg h \frac{\bar{v}_{h_2} (\lg h - \lg h_1) - \bar{v}_{h_1} (\lg h - \lg h_2)}{\lg h_2 - \lg h_1} + \\ & + 0,09 \frac{\bar{v}_{h_2} (\lg h - \lg h_1) - \bar{v}_{h_1} (\lg h - \lg h_2)}{\lg h_2 - \lg h_1} + 0,7, \end{aligned} \quad (6)$$

in particular,

$$\sigma_h \approx 0,12 \lg h \frac{\bar{v}_{1000} (\lg h - 1) - \bar{v}_\phi (\lg h - 3)}{2} +$$

$$+ 0,09 \frac{\bar{v}_{1000} (\lg h - 1) - \bar{v}_\phi (\lg h - 3)}{2} + 0,7. \quad (6')$$

$\phi = v = \text{vane}$.

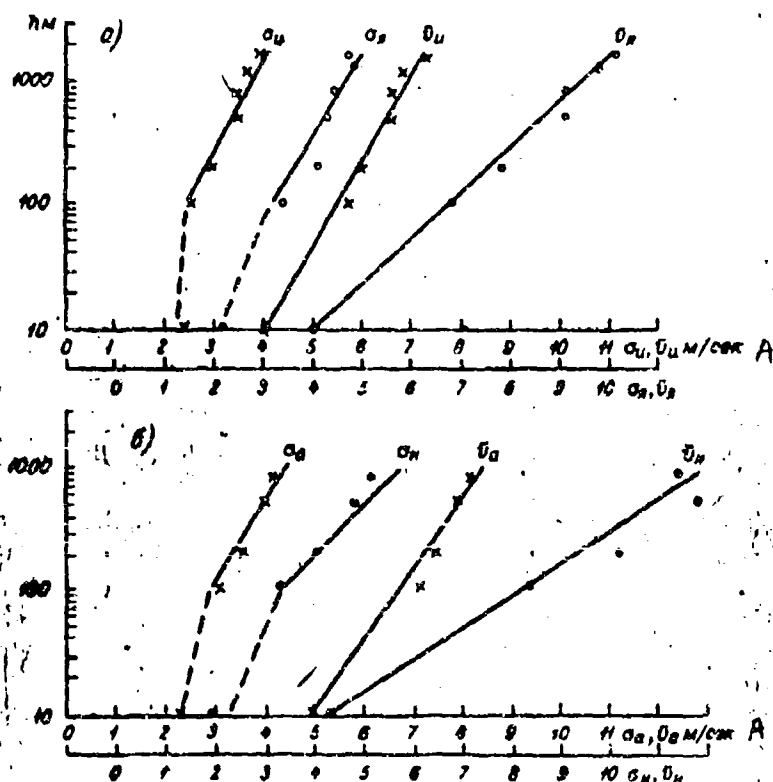


Fig. 3. Vertical profiles \bar{v} and $\bar{\sigma}$, \bar{v}_{Jan} , \bar{v}_{July} , \bar{v}_{Apr} and \bar{v}_{Nov} are the wind velocity profiles for January, July, April and November respectively, σ_{Jan} , σ_{July} , σ_{Apr} , and σ_{Nov} are the standard deviation profiles for winds in January, July, April and November respectively. a) Kiev, b) Minsk. ϕ = Jan; λ = July; a = April; H = November. A) m/sec.

In Figure 3 we show several examples for the two aerological stations when $\bar{v}_v > 4$ m/sec. For Kiev we used data for January and July for 1400 hours and for Minsk for April at 1330 hours and for November at 1930 hours.

Here it can be seen graphically that the agreement of empirical and computed data for the reduced relations is satisfactory.

It should be noted that for foreign areas we do not receive observational data for the boundary layer wind regime. However, even under these conditions by using the mean monthly wind velocity given in aeroclimatological atlases for the isobaric surface closest to the ground and also knowing the mean monthly wind velocity at the vane level it is possible to use the expressions derived above for a rough determination of the mean monthly velocity for the corresponding levels and its variability in the entire boundary layer.

BIBLIOGRAPHY

1. A. B. Kalinovskiy and N. Z. Pinus, Aerologiya (Aerology), Gidrometeoizdat, Leningrad, 1961.
2. P. A. Vorontsov, Metodika Aerologicheskikh Issledovaniy Pogranichnogo Sloya Atmosfery (Methods for Aerological Study of the Boundary Layer), Gidrometeoizdat, Leningrad, 1961.
3. M. S. Akhmetov, "On the Use of Radiosonde Data for Studying the Atmospheric Boundary Layer", Trudy GGO (Transactions of the Main Geophysical Observatory), No. 205, 1967.
4. S. A. Sapozhnikova, "Experience in Determining the Influence of the Underlying Surface on the Change in Wind Velocity with Altitude in the Lower 100-meter Layer of the Atmosphere", Trudy NIIAK (Transactions of the Scientific Research Institute of Aeroclimatology), No. 43, 1967.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

Foreign Science and Technology Center
US Army Materiel Command
Department of the Army

2a. REPORT SECURITY CLASSIFICATION

UNCLASSIFIED

2b. GROUP

3. REPORT TITLE

SOME CHARACTERISTICS OF VERTICAL VARIABILITY OF THE WIND VELOCITIES IN THE
ATMOSPHERIC BOUNDARY LAYER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Translation

5. AUTHOR(S) (First name, middle initial, last name)

P. A. Pershina

6. REPORT DATE

8 3 OCT 1969

7a. TOTAL NO. OF PAGES

7

7b. NO. OF REFS

N/A

8a. CONTRACT OR GRANT NO.

a. PROJECT NO.

02RD500

AMSEL-WL-MF

8b. ORIGINATOR'S REPORT NUMBER(S)

FSTC-HT-23- 013-70

8c. OTHER REPORT NUM(S) (Any other numbers that may be assigned this report)

ACSI Control Number J-7287

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

US Army Foreign Science and Technology
Center

13. ABSTRACT

The climatology of the boundary is still very poorly developed because research in this field has really only begun. For this reason it is not without interest to give an analysis of some characteristics of the vertical variability of wind velocity based on an analysis of empirical data.

The analysis was based on data from rawin sounding at aerological stations in the USSR (Kiev, Leningrad, L'vov, Minsk, Moscow, and Riga) during the period from 1959 through 1963. These data were used in computing the mean and mean square deviations of wind velocity from the vane both for altitudes 0.1, 0.2, and 0.5 km above the ground surface and for 1.0, 1.5, 2.0, and 3.0 km above sea level. In the computations it was taken into account that for a number of known reasons the maximum loss of wind information will be at the level $h = 0.1$ km. Accordingly, in order to ensure uniformity of a series of observations in the case of lack of data for the mentioned level data for the remaining levels are excluded during analysis.

DD FORM 1473

REPLACES DD FORM 1473, 1 JAN 60, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Atmospheric boundary layer Vertical variability of wind Mean deviations of wind velocity Mean square deviations of wind velocity Radiosonde data						

UNCLASSIFIED
Security Classification